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Epidemiological Trends of Fungal Pulmonary Infections Post-COVID-19

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ABSTRACT

Background: Fungal infections of the lungs have developed into a significant concern after COVID-19, especially for patients with predisposing risks like diabetes and previous use of corticosteroids. The combination of clinical signs with viral pneumonia frequently results in missing the diagnosis and negative consequences. To assess the epidemiological characteristics, risk factors, clinical presentation, and outcomes of patients who developed fungal pulmonary infections after recovering from COVID-19. **Methods:** This was a cross-sectional study conducted from July 2023 to July 2024 at the department of Medicine, DHQ hospital, Lodhran and it included 82 post-COVID patients with pulmonary fungal infections. Demographic information, comorbidities, treatment history of COVID-19, classification of the fungal infection, and the outcomes of the disease were analyzed in SPSS version 25. Statistical relations were tested using the chi-square test and Fisher's exact test. **Results:** Most of the patients were males (65.9%) and above 40 years. The diabetes mellitus incidence (52.4%) and history of corticosteroid use (68.3%) were markedly linked with fungal infection. Most frequent pathogens were aspergillus (45.1%) and mucormycosis (26.8%). The most prevalent symptoms were cough, fever, and dyspnea. The recovery rate was at 74.4% and mortality rate was at 14.6%. **Conclusion:** Fungal pulmonary infections post-COVID-19 are linked with severe disease and high morbidity, especially in patients with diabetes or who received immunosuppressive therapy. Early recognition and targeted treatment are crucial to improve outcomes.

INTRODUCTION

The COVID-19 pandemic has given rise to a multitude of clinical challenges both during its acute phase and in the subsequent recovery period. One of the most concerning issues is the opportunistic fungal infections of the lungs, particularly concerning in those with weakened immune systems or other metabolic conditions. While pulmonary fungal infections were, and still are, seen as a complication from immunocompromised states like cancer or HIV, the post-COVID-19 world has transformed this paradigm [1-3].

Invasive fungal infections have increased in patients recovering from COVID-19 who were treated with corticosteroids, broad-spectrum antibiotics and oxygen therapy. Loss of mucosal immunity alongside mechanical ventilation, glucose metabolism, and other factors encourages fungal colonization and invasion. In addition, the clinical signs of these fungal infections are often masked by post COVID pneumonia, complicating an early diagnosis [4-6].

Mucormycosis cases surged in the media as "black fungus" during the second wave of the pandemic. especially in South Asia. However, less dramatic but equally life-threatening infections like pulmonary aspergillosis or candidiasis have also increased. These infections have a tendency to remain undiagnosed until severe damage has been inflicted on the lungs, ultimately resulting in increased illness, extended inpatient care, and exorbitant expenses for patients and healthcare systems [7-9].

While isolated case reports and hospital-based observations have described these trends, there remains a need for structured data outlining the demographic patterns, risk factors, and clinical outcomes associated with fungal lung infections in post-COVID patients. This study was designed to bridge that gap by analyzing epidemiological trends over a one-year period in a tertiary care setting. By identifying at-risk populations and common clinical presentations, we aim to contribute to

early recognition, preventive strategies, and better management of fungal pulmonary infections in the post-COVID era.

METHODOLOGY

This cross-sectional observational study was conducted at the department of Medicine, DHQ hospital, Lodhran from July 2023 to July 2024. The objective was to determine the epidemiological features and the results of the patients who developed pulmonary fungal infections after recovering from COVID-19.

The study involved 82 patients. These patients had a documented history of SARS-CoV-2 infection which was confirmed through either RT-PCR or HRCT chest during the acute illness phase. They also developed pulmonary fungal infections later in the course. Patients were sampled using consecutive non-probability sampling from the inpatient and outpatient departments. Patients with incomplete documents, as well as with non-respiratory fungal infections, were excluded from the final analysis.

Clinical and demographic data were extracted from patient files, electronic hospital records, and structured proformas. Variables collected included age, gender, residential background (urban/rural), history of COVID-19-related hospitalization, use of corticosteroids, and need for oxygen or ventilator support during their COVID-19 illness. Comorbid conditions such as diabetes mellitus, chronic lung disease, chronic kidney disease, immunosuppressive states, and smoking history were also recorded.

The diagnosis of fungal pulmonary infection was based on clinical presentation, radiological findings (mainly high-resolution computed tomography of the chest), and microbiological evidence including sputum culture, bronchoalveolar lavage (BAL), galactomannan levels, and where available, histopathological confirmation. Each case was classified according to the type of fungal infection: aspergillosis, mucormycosis, candidiasis, cryptococcosis, or histoplasmosis.

Treatment details included use of antifungal medications, surgical interventions when applicable, duration of hospital stay, and requirement of intensive care unit (ICU) admission. Final outcomes were categorized as recovered, still admitted, or deceased.

Data were entered and analyzed using SPSS version 25. Frequencies and percentages were calculated for categorical variables. The chi-square test (or Fisher's exact test where appropriate) was used to assess associations between risk factors and outcomes. A p-value less than 0.05 was considered statistically significant.

RESULTS

The study included 82 patients diagnosed with fungal pulmonary infections after recovering from COVID-19. A significant number of cases were observed in the 41–60 age group (40.2%), followed by individuals above 60 years (37.8%), indicating that middle-aged and elderly patients were at greater risk (p = 0.048). Male patients represented a larger portion of the study population (65.9%), and this gender difference was statistically significant (p = 0.011). Most participants belonged to urban areas, although no significant association was found between location and infection (p = 0.237). Three-fourths of the patients had been hospitalized during their COVID-19 illness (74.4%), and this history was significantly linked to later fungal infection (p = 0.022). A high proportion (68.3%) had received corticosteroid therapy during their COVID treatment, which showed a significant association with fungal complications (p = 0.019). Likewise, 58.5% had required oxygen therapy or ventilatory support, which also showed a significant link (p = 0.030). These findings highlight the influence of COVID-19 severity and its management as contributing factors in post-recovery fungal infections.

Table 1

Demographic and COVID-19 History (n = 82)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Age Group (years)	< 40	18	22.0	0.048*
	41–60	33	40.2	
	> 60	31	37.8	
Gender	Male	54	65.9	0.011*
	Female	28	34.1	
Residential Area	Urban	49	59.8	0.237
	Rural	33	40.2	
Hospitalized for COVID-19	Yes	61	74.4	0.022*
Received Corticosteroids	Yes	56	68.3	0.019*
Oxygen or Ventilation Support	Yes	48	58.5	0.030*

Among the patients analyzed, diabetes emerged as the most prevalent comorbidity, found in over half of the cases (52.4%). This association was highly significant (p = 0.001), underscoring diabetes as a major risk factor for fungal infections post-COVID. Chronic lung disease was also common (26.8%) and significantly related to infection risk (p = 0.041). Other conditions such as chronic kidney disease and malignancy or immunosuppression did not show statistically meaningful associations in this cohort. A noteworthy portion of the patients (35.4%) were either current or former smokers, bordering on significance (p = 0.052), which may suggest a role in increased vulnerability, though more data would be needed. HIV infection was rare and not associated with outcomes in this group. Overall, metabolic and respiratory comorbidities seemed to predispose individuals more than immunocompromised states.

Table 2

Comorbidities and Risk Factors

Variable	Category	Frequency (n)	Percentage (%)	p-value
Diabetes Mellitus	Yes	43	52.4	0.001*
Chronic Lung Disease	Yes	22	26.8	0.041*
Chronic Kidney Disease	Yes	11	13.4	0.297
Malignancy/ Immunosuppression	Yes	10	12.2	0.089
Smoking Status	Current/Former	29	35.4	0.052
HIV Positive	Yes	3	3.7	0.812

Cough was the most frequently reported symptom, present in nearly 83% of patients, followed by fever (74.4%) and shortness of breath (68.3%). These symptoms showed significant associations with fungal infection severity (p-values < 0.05), indicating that

respiratory distress is a primary clinical feature in these cases. On the other hand, hemoptysis was reported in 17.1% of patients but did not reach statistical significance. In terms of fungal pathogens, aspergillosis was the most common infection diagnosed (45.1%), followed by mucormycosis (26.8%) and candidiasis (15.9%). Aspergillosis showed a significant relationship with previous COVID-19-related factors and outcomes (p = 0.027), reflecting a growing clinical trend of invasive pulmonary aspergillosis in post-COVID patients. Less common infections included cryptococcosis and histoplasmosis, suggesting these were opportunistic and less dominant in the post-COVID landscape.

Table 3

Clinical Presentation and Type of Fungal Infection (n = 82)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Symptoms	Cough	68	82.9	0.005*
	Fever	61	74.4	0.009*
	Dyspnea	56	68.3	0.016*
	Hemoptysis	14	17.1	0.338
Type of Fungal Infection	Aspergillosis	37	45.1	0.027*
	Mucormycosis	22	26.8	
	Candidiasis	13	15.9	
	Cryptococcosis	6	7.3	
	Histoplasmosis	4	4.9	

The vast majority of patients (96.3%) were managed with antifungal therapy, indicating that pharmacologic treatment remains the cornerstone of care for fungal pulmonary infections. Despite this, around 16% of cases required surgical intervention, typically in more invasive infections like mucormycosis. Surgical treatment showed a statistically significant association with outcome severity (p = 0.044), underscoring its role in advanced disease management. More than half of the patients (58.5%) had hospital stays exceeding 10 days, and 25.6% required ICU-level care, both reflecting substantial disease burden and statistically significant associations (p = 0.037 and 0.029, respectively). In terms of clinical outcomes, 74.4% of patients recovered fully, while 14.6% died, and 11% remained admitted at the time of analysis. The outcome differences were statistically significant (p = 0.001), highlighting the serious prognosis associated with fungal infections in post-COVID patients, especially when compounded by comorbidities or delayed presentation.

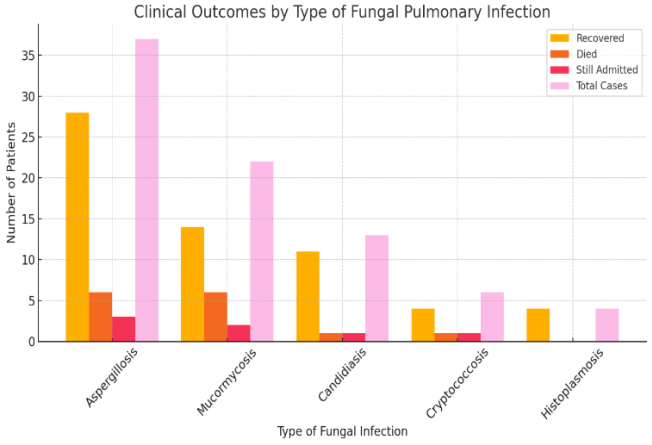
Table 4

Treatment and Clinical Outcomes (n = 82)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Antifungal Therapy Given	Yes	79	96.3	–
Surgical Intervention	Yes	13	15.9	0.044*
Hospital Stay Duration	> 10 days	48	58.5	0.037*
ICU Admission for Infection	Yes	21	25.6	0.029*
Outcome	Recovered	61	74.4	0.001*
	Died	12	14.6	
	Still Admitted	9	11.0	

Figure 1: Graph showing the clinical outcomes (recovered, died, still admitted) for each type of fungal pulmonary infection. The total number of cases for each type is also included as a reference. This visualization highlights that aspergillosis and mucormycosis had the highest mortality and still-admitted cases, indicating their relatively severe course in post-COVID patients.

Figure 1



DISCUSSION

The present study highlights the evolving burden of fungal pulmonary infections in individuals recovering from COVID-19, with significant epidemiological patterns that demand clinical attention. A noticeable trend was the predominance of cases in males and middle-aged to older adults, consistent with previous research. Studies similar demographic pattern, where males over 40 showed greater susceptibility to post-COVID fungal complications, particularly due to cumulative risk from comorbidities and oxygen dependency [10-12].

Among the major predisposing factors, a history of corticosteroid therapy and oxygen or ventilator support during COVID-19 illness were significantly associated with the development of fungal infections in our cohort. This was in line with studies that identified immunosuppressive therapy and mechanical ventilation as key contributors to secondary invasive fungal infections such as pulmonary aspergillosis [13-15].

Diabetes mellitus emerged as the most common comorbidity in our study, present in over half of the patients. This correlation has been well-established in the literature. Studies emphasized the role of uncontrolled hyperglycemia in impairing innate immunity and facilitating fungal colonization, particularly in the context of mucormycosis. The rise in mucormycosis cases during the second wave of COVID-19 in South Asia further supports the association between COVID-19, diabetes, and fungal infections [16-18].

Clinically, cough, fever, and dyspnea were the dominant presenting symptoms in this cohort, which are often indistinguishable from post-viral or bacterial pulmonary syndromes. Therefore, a high index of suspicion is crucial. Aspergillosis was the most commonly diagnosed infection in our series, consistent with studies from both high- and low-income settings [19]. While mucormycosis drew global attention due to its aggressive course and need for surgical management, candidiasis and other rare fungal infections like cryptococcosis and histoplasmosis also made up a non-negligible portion of cases.

The majority of patients were treated successfully with antifungal therapy, yet a notable fraction required surgical

debridement. Outcomes varied with disease severity and underlying comorbidities. The mortality rate observed in our study (14.6%) aligns with study who noted increased mortality in COVID-associated pulmonary fungal infections, especially among ICU patients and those presenting late. The need for ICU care and prolonged hospital stay in many patients also reflects the severe course of disease, echoing the burden seen in other respiratory fungal outbreaks post-viral pandemics[20].

Although antifungal agents remain the cornerstone of treatment, delays in diagnosis and resource limitations in imaging and microbiology may compromise timely care. This highlights the importance of early screening in high-risk patients, particularly those with diabetes and prolonged steroid use.

CONCLUSION

Fungal pulmonary infections following COVID-19 represent a significant and potentially life-threatening complication, especially in patients with diabetes, those exposed to corticosteroids, and individuals requiring intensive respiratory support. The predominance of aspergillosis and mucormycosis in this population underscores the need for heightened clinical awareness and prompt intervention. Early identification, multidisciplinary management, and close monitoring of high-risk patients are essential to improve outcomes and reduce mortality in the post-COVID era.

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